H2 SAFETY Snapshot

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IDENTIFYING SAFETY VULNERABILITIES

What Is It?

Identification of Safety Vulnerabilities (ISV) is an organized effort to identify and analyze the significance of hazards associated with a process or activity (i.e., a hazard analysis). Doing a hazard analysis will help you 1) see any unacceptable risks you might face when working with hydrogen and 2) determine your options for managing or eliminating those risks.

Why Do I Need It?

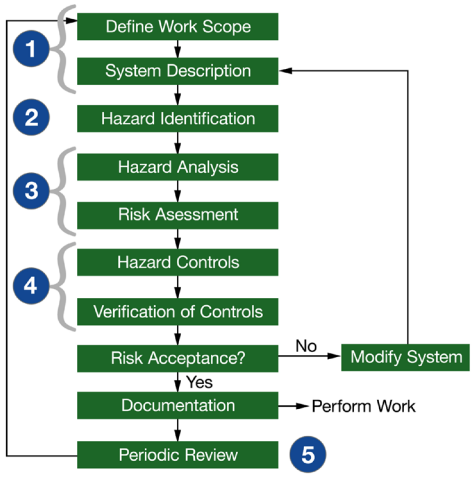
Hazard analysis can shine a spotlight on facility design problems and unsafe hydrogen operations that could cause property damage, injuries, or even death. Once the problems are brought to light, you can identify risk management strategies to address them. Done correctly, hazard analysis helps a project team identify potential safety issues, discover ways to lower the probability of an occurrence, and minimize the associated consequences.

Who Should Be Involved?

The hazard analysis team should have sufficient expertise in all aspects of the work being analyzed. At least one team member should have experience and knowledge specific to the hydrogen project, process, equipment, and/or facility being evaluated, and at least one team member should be skilled in the hazard analysis method being used. It is also important to include someone with knowledge of hydrogen properties (e.g., flammability and ease of ignition) and someone who is aware of the codes and standards pertinent to the project and facility.

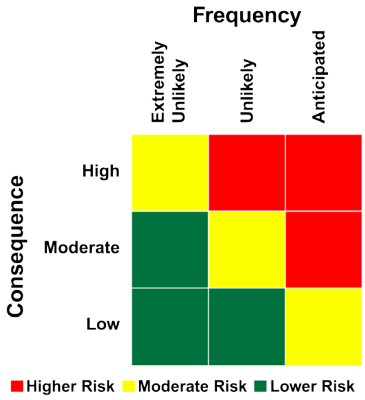
How Do I Perform A Hazard Analysis?

Perform the hazard analysis at the project's earliest stages using any of the established industry methods described on page 2.



A hazard analysis typically consists of the five major steps shown in the graphic to the right (see **Safety Planning Guidance for Hydrogen and Fuel Cell Projects** in the list of Helpful Resources on page 2 for more information).

Once the hazards are identified, their risks should be categorized in terms of potential impact (consequence) and probability of occurrence (frequency). For example, a very-low-probability risk might be one that is not likely to occur in the 50-year expected operating lifetime of the process, and a low-probability risk might be one that is likely to occur just once in the process lifetime. A medium-probability risk might be likely to occur a few times in the process lifetime, a high-probability risk might be likely to occur once a year or whenever an operator is working in a highly stressed condition without immediate oversight, and a very-high-probability risk might be likely to occur during every equipment maintenance/repair outage or at least a few times each year. The impact categorization scheme might be in terms of the severity of a potential personnel injury and/or the extent of equipment damage and lost production.



After the risks are categorized, hazard controls should be developed to eliminate or reduce the probability, consequences or both. The highest risks should receive the most attention.

Tips for a Successful Hazard Analysis

- Allow ample time over multiple sessions. Don't rush through it.
- Bring easily accessible data on equipment design and operation, expected range of operating parameters, startup and shutdown procedures, and required maintenance operations.
- Don't get bogged down by one difficult event or failure mode. Postpone completion of that event or failure mode until additional pertinent resources and information (and possibly another participant) become available.
- Bring plenty of coffee and other refreshments to each session.
- Maintain a spirit of congeniality and interject healthy doses of good humor.

Safety starts with planning, and planning starts with hazard analysis

Hazard Analysis Methods

FMEA (Failure Modes and Effects Analysis): A systematic method for examining the effects of component failures on system performance and surroundings. FMEA determines which initiating events (component failures, operating conditions, external events, etc.) will lead to significant adverse consequences that can compromise safety.

"What If" Analysis: A speculative process where questions of the form "What if … (hardware, software, instrumentation, or operators) (fail, breach, break, lose functionality, reverse, etc.)…?" are formulated and answered in a way that can identify potentially unacceptable risks.

HAZOP (Hazard and Operability Analysis): A method developed to identify both hazards and operability problems at chemical process plants. It systematically evaluates the impacts of deviations in process parameters (e.g., pressure, temperature, flow rate) using guide words (e.g., higher, lower, no) to uncover potential hazards/risks associated with changes from normal operating conditions.

Checklist Analysis: A method to evaluate the project against existing guidelines using a series of checklists. It is most often used to evaluate a specific design, piece of equipment, or process for which an organization has significant experience, and for which written guidelines or standards are available.

Fault Tree Analysis: A deductive (top-down) method used to identify and analyze conditions and factors that can cause a failure or undesirable event. This method addresses the possibility of various combinations of failures, contributing events, and conditions.

Event Tree Analysis: An inductive approach used to identify the spectrum and severity of possible outcomes and determine their likelihoods. The analysis starts with an initiating event or initial condition and includes the identification of a set of success and failure events that are combined to produce various outcomes.

Probabilistic Risk Assessment: An organized process for answering and often quantifying the following three questions:

1. What can go wrong?
2. How likely is it to happen?
3. What are the consequences?

PRA is usually the most demanding hazard analysis technique in terms of staffing and resources, but it often produces the most complete and thoroughly documented analysis.

Hydrogen Hazards to Consider

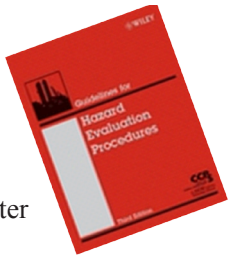
Earlier surveys of hydrogen-related work have elicited a number of common responses on hazard identification as a first step toward managing or eliminating risk. Two questions to consider:

What hydrogen hazard has the potential to result in the worst consequence?

This could include uncontrolled hydrogen release from equipment failure (resulting in concentration greater than the lower flammability limit); flammable mixture exposed to ignition source (resulting in fire or explosion); excess pressure buildup inside equipment (resulting in loss of containment and fire or explosion); unexpected rapid reaction with energetic materials that can't be controlled; etc.

What hydrogen hazard is the most likely to occur?

This could include hydrogen leaks, minor burns, exposure of energetic/reactive materials to air or water, etc.



Helpful Resources

- Guidelines for Hazard Evaluation Procedures (3rd Edition), AIChE Center for Chemical Process Safety, 2008 (www.aiche.org/Publications/pubcat/listings/081690491X.aspx)
- Safety Planning Guidance for Hydrogen and Fuel Cell Projects, April 2010, U.S. Department of Energy Fuel Cell Technologies Program (www.h2bestpractices.org/safety_planning)
- FMEA Info Centre, a non-commercial web-based inventory dedicated to the promotion of FMEA (www.fmeainfocentre.com/)

For Laboratories, Did You Know

NFPA 45, *Fire Protection for Laboratories Using Chemicals*, requires "evaluations be made for hazards that can be encountered or generated during the course of the work", BEFORE laboratory tests or chemical reactions are begun.

Topic for Next Quarter

Ventilation

PNNL-SA-77099

Topic suggestions? Comments?
Contact us at snapshot@pnl.gov

A safety knowledge tool from U.S. DEPARTMENT OF ENERGY | Pacific Northwest NATIONAL LABORATORY